Radionuclide Contamination in the Rocky Flats National Wildlife Refuge

Abstract: *Beginning with the Rocky Flats National Wildlife Refuge Act of 2001 (the Act), the former Rocky Flats Nuclear Weapons Plant operated by DOE started its transformation into a wildlife refuge with the objective of preserving the unique vegetational habitats and the wildlife that they support. The Act requires that, under EPA supervision, DOE must demolish the former nuclear weapons manufacturing facilities then ameliorate the areas with the most dangerous levels contamination from plutonium, other transuranic elements, and industrial pollutants. Recently, development interests have offered to purchase from the U.S. Fish and Wildlife Service a 300-foot wide right-of-way along Indiana Street set aside by the Act for transportation improvements—an area that is known to be highly contaminated with plutonium, americium, and other transuranic elements—so that a number of proposed large-scale construction projects may be enabled. At present several local governments are advocating for these construction projects while completely ignoring the risk to public health that would ensue if they are constructed. The origin, causes, and extent of the public health risk—primarily from airborne resuspended respirable radionuclide contamination from within and nearby the site—are described. Additionally, specific recommendations regarding radionuclide sampling and remediation are offered while development of any sort within the refuge is strongly discouraged.* COLORADO ENVIRONMENTAL ANALYTICS, *March 6, 2012*

Introduction and Background

Enactment of the Rocky Flats National Wildlife Refuge Act of 2001 (the Act) started the transformation of the 6,240 acre former Rocky Flats Nuclear Weapons Plant operated by DOE into a wildlife refuge with the objective of preserving the site's unique vegetational habitats and the wildlife that they support. The Act requires DOE to demolish the former nuclear weapons manufacturing facility, accurately assess the industrial site for contaminants, then ameliorate areas found to have dangerous levels of radionuclides, heavy metals, and other industrial pollutants. The Act also requires DOE to follow applicable law—specifically the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA)—to develop a long-term management plan that will protect the health and safety of not only those entering the site but also those who live and work within nearby communities. While retaining the 929 acre Central Operable Unit (OU) as well as additional areas, in July 2007 DOE transferred administrative control of the Peripheral OU (the remaining 3,953 acres of the refuge) to the U.S. Fish and Wildlife Service (USFWS)—see Figure 1 for details.

According to the Act, if certain strict criteria are met, the Secretaries of Energy and of the Interior are required to "...make available land along the eastern boundary of Rocky Flats for the sole purpose of transportation improvements along Indiana Street." Acting on behalf of the Rocky Flat National Wildlife Refuge (RFNWR), in late 2011 USFWS initiated an Environmental Assessment (EA) under provisions of the National Environmental Protection Act (NEPA) to carry out this requirement of the Act. Subsequently, the Jefferson Parkway Public Highway Authority (JPPHA)—a governmental subdivision of the State of Colorado created by Jefferson County, the City of Arvada, and the City and County of Broomfield—presented an offer to purchase the subject 300-foot wide ROW from USFWS to construct a privately operated, for profit four-lane tollroad.

Despite persistent opposition from the public, the known risks to public health that would ensue, and the serious but as yet unaddressed traffic-pattern impacts to the City of Golden, the County of Jefferson, the City of Arvada, and the City and County of Broomfield have long advocated for the construction of the proposed tollroad in order to enable follow-on construction of more than 11,000,000 square feet of commercial space and more than 4,500 residential housing units in areas adjacent to and fed by the proposed tollroad.

Finally, the City of Golden also presented a competitive offer to USFWS to purchase the ROW proposing that it be used to create a bikeway that would be integrated with the wildlife refuge and surrounding open space areas.

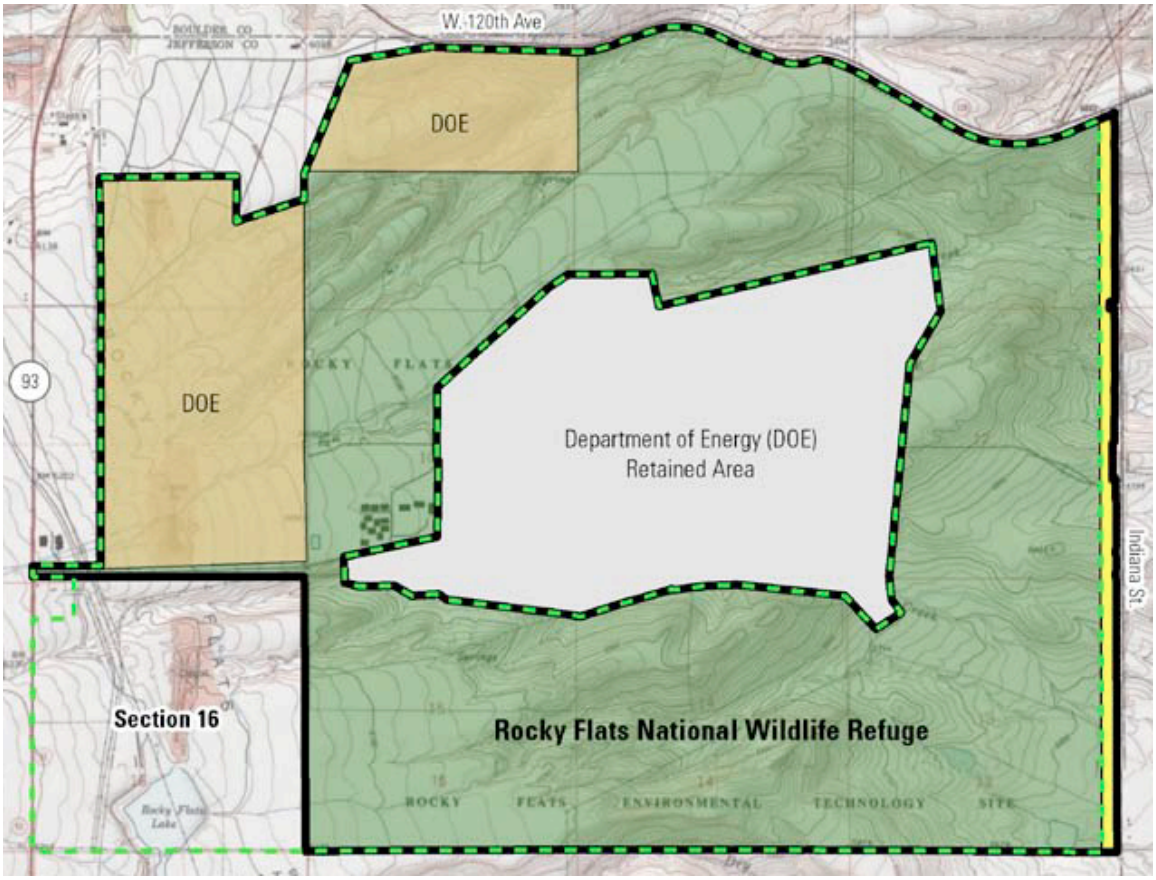

Figure 1: Rocky Flats National Wildlife Refuge and DOE Retained Areas.

Rocky Flats National Wildlife Refuge Environmental Assessment

During the EA conducted by USFWS between July and December 2011, the Service received comments from more than a dozen regional community, environmental, and scientific groups, the preponderance of whose commenters, opposed transferring the Indiana Street ROW to JPPHA urging instead a thorough Environmental Impact Statement (EIS) that would examine the impacts of such a transfer. Additionally, USFWS received comments from well over 1,250 members of the public, the preponderance of whom, again, opposed the transfer of the ROW to JPPHA but instead urged a thorough EIS.

Clear evidence was presented by EA commenters showing that the *Corrective Action Decision/Record of Decision for Rocky Flats Plant (USDOE) Peripheral Operable Unit and Central Operable Unit* (CAD/ROD)[1] issued in late 2006 was seriously deficient in that it failed to model the health risks due to the resuspension of respirable Pu, Am, and other transuranics that would occur during proposed tollroad construction, operational, and maintenance activities—affecting not only construction workers but also those living and working in downwind communities—showing that a thorough EIS was required prior to the proposed ROW transfer. Arguably, USFWS violated the provisions of NEPA when it issued a Finding Of No Significant Impact (FONSI) then provisionally transferred the ROW to JPPHA. Subsequently, the Town of Superior, City of Golden, WildEarth Guardians, and Colorado Mountain Wild have filed complaints against USFWS and certain of its managing officials in Federal District Court.

In the following sections, several subjects are examined including: the principal sources and levels of

[1] RI/FS refers to the *RCRA Facility Investigation – Remedial Investigation/Corrective Measures Study – Feasibility Study Report for the Rocky Flats Environmental Technology Site*, June 2006; WRW refers to a Wildlife Refuge Worker; and CERCLA refers to the Comprehensive Environmental Response, Compensation, and Liability Act of 1980.

radionuclide contamination originating from the former Rocky Flats Nuclear Weapons Plant; the inadequacy of the public health risk modeling and action level criteria used during Comprehensive Risk Assessment (CRA) performed by DOE prior to closure; the inadequacy of the soils, sediments, and air radionuclide contaminant sampling methodologies used by DOE to develop its CRA model; and the serious public health risks due to resuspended, respirable plutonium and americium is described. Additionally, the results of several epidemiological studies of the health risks associated with human intake of radionuclides are presented. Finally, the efficacy of the sampling and assay methodologies used for analysis of radionuclide contamination in the soils, sediments, and the air of the wildlife refuge are critically examined.

Sources of Contamination from the Rocky Flats Nuclear Weapons Plant

Since it began operation in 1953, the Rocky Flats Nuclear Weapons Plant has released significant levels of plutonium, americium, and other transuranic radionuclides as a result of a number of incidents including two major fires (1957 and 1969), a large release of Pu-laden cutting oil into the soil from nearby openly exposed steel storage drums, and a release of Pu into the air in 1974. After several thorough investigations, the consensus conclusion was that the major sources of contamination from radionuclides is considered to be the 1957 fire and the cutting oil leakage from corrosion of the steel drums. In 1970 the first definitive study regarding the release and dispersal pattern of Pu in the local environment was undertaken by the then U.S. Atomic Energy Commission's Health and Safety Laboratory entitled *Plutonium in Soil Around the Rocky Flats Plant* published by P.W. Krey and E.P. Hardy August 1st, 1970 in New York, New York.[2]

The map shown in Figure 2, derived from the Krey and Hardy study, illustrates the dispersal pattern of released Pu described by a set of isopleths that indicate average levels of contamination in becquerels/meter^2 (Bq/m^2).[3] As the map shows, the area of highest soil contamination is near the geographic center of the former Rocky Flats Nuclear Weapons Plant but it also shows that high levels of Pu contamination form vectors to the east, southeast, and south—fully encompassing the Indiana Street ROW. It is important to understand the significance of the dispersal pattern shown in the figure: for example, the contamination near the geographic center of the former Industrial Area (IA) shows that the contamination level measured was on the order of 74,000 Bq/m^2. However, the levels shown by the map are average contamination level values that allowed Krey and Hardy to draw the set of isopleths for the larger geographic area. The levels of contamination actually measured and reported ranged from 100,000 - 180,000 Bq/m^2. Importantly, these levels range from 1,800 to more than 3,200 times the estimated Pu background level, respectively. These levels of Pu contamination in the soil far exceed levels allowed by the State of Colorado and represent a highly concentrated source of respirable Pu available for airborne transport to the Indiana Street ROW as well as to communities further to the east, southeast, and south.

The second definitive study was initiated by the late Carl J. Johnson, MD between 1973 and 1977 while he was the Director of the Jefferson County Colorado Health Department. During this period, Johnson and his collaborators performed pioneering work regarding—not only the health effects of resuspended respirable Pu when it becomes airborne—but also the proper techniques for accurately measuring the levels of Pu available for resuspension in the context of specific soil environment scenarios.[4] Specifically, field work performed during their study analyzed soil samples from within the area of the Indiana Street ROW. After performing careful radiochemical analysis it was determined that the levels of Pu found in the Section 7 locality were on the order of 60 to 170 dpm/g—consistent with earlier findings by Krey and Hardy—but

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[2] This study is available at: http://www.osti.gov/bridge/servlets/purl/4071339-IFcd8O/4071339.pdf.

[3] The Bq is the standard international unit for radioactivity: one Bq is the quantity of a specific radioactive material in which one nucleus decays, emitting a burst of radiation, per second.

[4] See Carl Johnson, R. R. Tidball, and R. C. Severson, *Plutonium hazard in respirable dust on the surface soil*, *SCIENCE*, volume 193, August 6, 1976, pages 488-490. In the study Johnson et. al. examine the then interim standard of 2.0 dpm/g for soils contaminated with Pu (established by the CDPHE (then the Colorado State Health Department)) (the C.J. Johnson plutonium study).

again far exceeding levels permitted by the State of Colorado.[5]

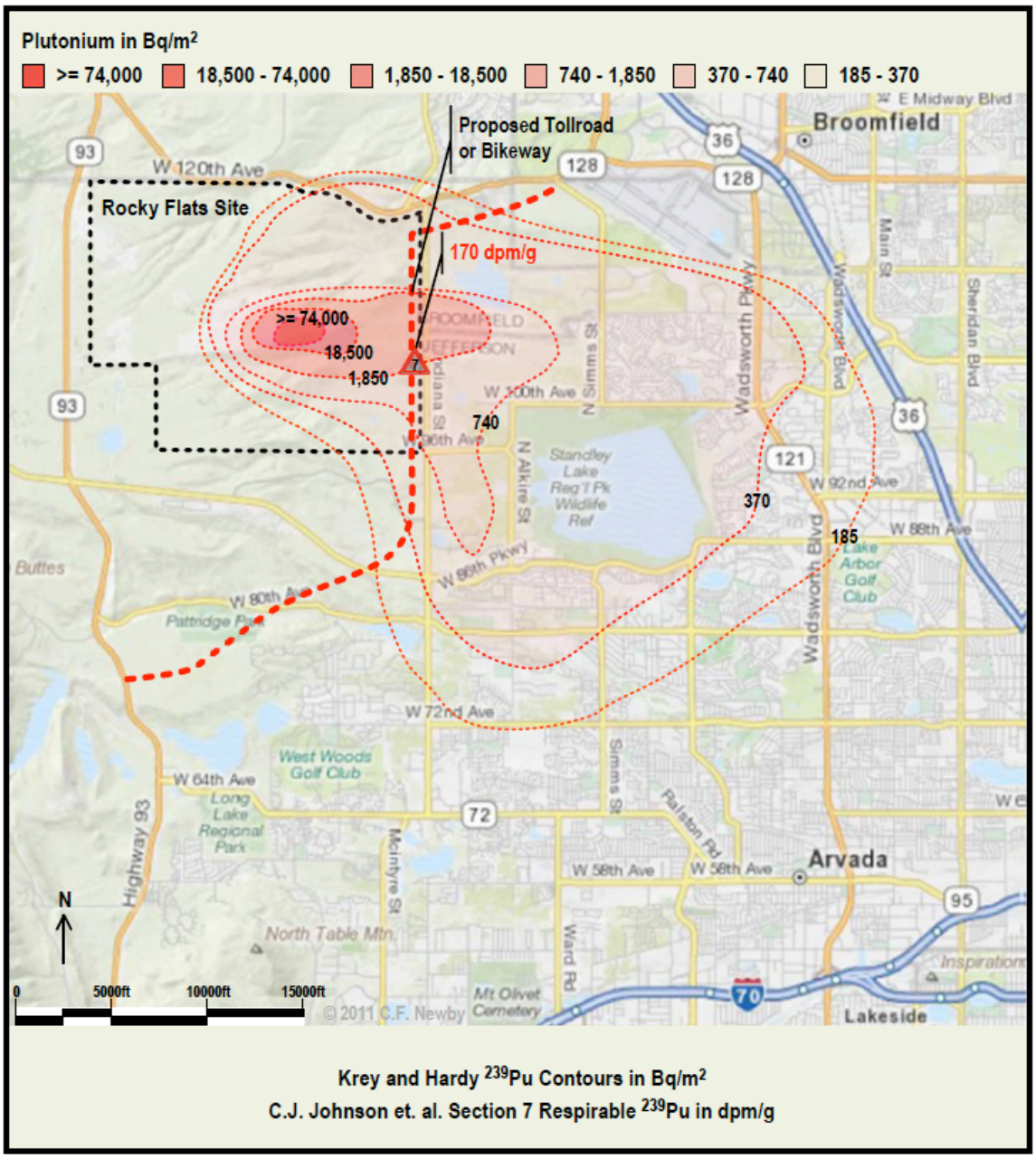
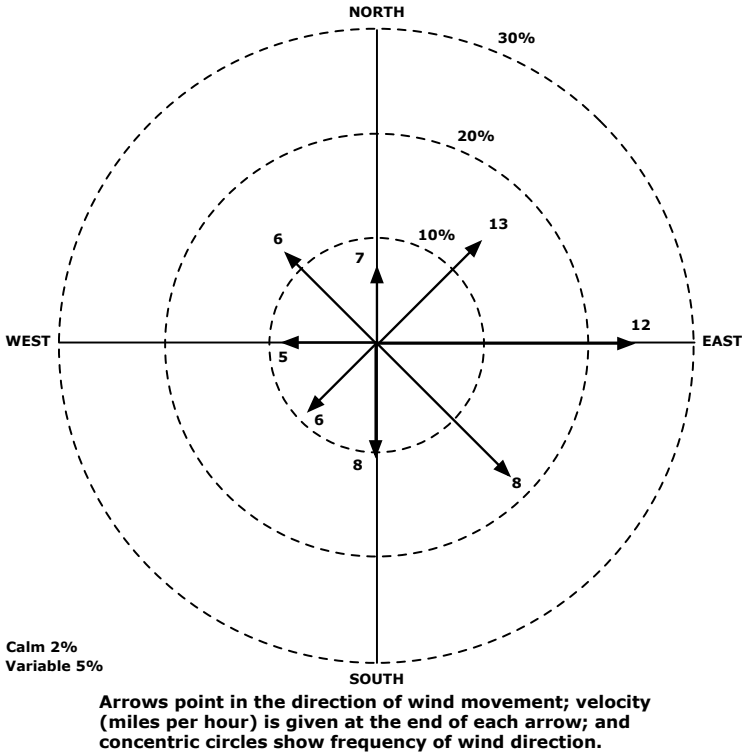


Figure 2: Plutonium 239 Contamination from the Rocky Flats Nuclear Weapons Plant.

As shown in Figure 2, sampling performed during the C.J. Johnson plutonium study in a locality that encompasses the Indiana Street ROW reveals Pu contamination levels even higher than those estimated in the Krey and Hardy study. Accounting for the Pu dispersal pattern presented in the Krey and Hardy study,

[5] As shown in Figure 2 below, in samples from the Section 7 locality along the Indiana Street ROW C.J. Johnson et. al. found the respirable dust fraction in the soils to be in the range of 170 dpm/g i.e., at 380 times the estimated background level for ^{239}Pu particles in the range of ≤ 5 μm in size.

NOAA monitoring of the Rocky Flats environment for wind direction and speed reports dominate vectors from the west and northwest—shown in Figure 3—with average speeds of 70 MPH or greater for between 5 and 10 days per year (with gusts of 125 MPH are typical during these events). It should be emphasized that, due to soil characteristics as well as other environmental factors, it is almost certain that nearly all the Pu found in the Krey and Hardy as well as the C.J. Johnson plutonium studies still exists in the soils and sediments along the Indiana Street ROW.[6]



Source: Krey and Hardy and C.J. Johnson Plutonium Studies.

Figure 3: Rose Diagram Showing Average Wind Direction and Velocity at Rocky Flats.

Moreover, the study makes the important point that within the then proposed Pu soil contamination standard of 2.0 dpm/g "no provision is made to prevent the treated soil from being recontaminated by redeposition of Pu from more high contaminated soils upwind." The authors conclude with the observation that the standard is inadequate recommending instead that the standard should be based on the respirable-dust fraction since it is these small particles ($\leq$ 5 μm) that have the greatest potential for resuspension and inhalation, therefore, the greatest potential for serious harm to public health.

Crucially, due to the high levels of Pu known to exist within the right-of-way, construction of the proposed four-lane freeway through the Indiana Street-to-CO93 alignment would almost certainly create levels of airborne resuspended respirable Pu, Am, and other transuranics that would have serious adverse health effects among highway workers as well as the people who live or work in the nearby and downwind communities.

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[6] In its 1990 - 1999 study, the Colorado Department of Public Health and Environment found that from 1953 through 1990, between 50 and 1100 grams of Pu were released offsite from the Rocky Flats plant—this amounts to between 5 and 80 Ci of plutonium or between 1.85×10^{11} and 2.95×10^{12} Bq. The *Summary of Findings, Historical Public Exposures Studies on Rocky Flats*, August 1999, CDPHE can be found at: http://www.cdphe.state.co.us/rf/bluesumm.htm#INDEX

RCRA Facility Investigation Public Health Risk Assessment Criteria is Deficient

The Rocky Flats Cleanup Agreement of 1996 (as amended) inexplicably sets the permissible Pu in the soil after cleanup to:

- Pu contamination in top 3 feet of soil= < 50 pCi/g
- Pu contamination at 3 - 6 feet= 1,000 - 7,000 pCi/g
- Pu contamination below 6 feet= essentially unlimited

This level of residual Pu does not compare favorably with other cleanup sites near urban areas: the level for the Livermore National Laboratory, California was set to 10 pCi/g; the level for the site at Fort Dix, New Jersey was set to 8 pCi/g; and the level at the Hanford, Washington reactor site was set to 34 pCi/g (even the Johnson Atoll bomb test site was cleaned up to a standard of 14 pCi/g). For reference, 50 pCi/g and 7,000 pCi/g are 1,000 and 140,000 times the background level for Pu along the Colorado Front Range respectively (the generally accepted background level of Pu is 0.025 - 0.05 pCi/g).

The risk to human health due to inhalation of resuspended respirable Pu, Am, and other transuranics is not currently known definitively; however, the C.J. Johnson cancer incidence study[7] of the population around the former Rocky Flats Nuclear Weapons Plant convincingly shows that the calculations for "excess" cancers used under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) underestimate the observed versus expected cancers by a factor of between 100 and 1000. That is, the radiological health risk assessment for radionuclides claimed in (8) is between $1x10^{-4}$ (1 in 10,000) and $1x10^{-6}$ (1 in 1,000,000) lifetime cancers but, based on the findings of the C.J. Johnson cancer incidence study, the future incidence of excess cancers for the population nearest RFNWR is likely to be $1x10^{-3}$ (1 in 1,000) for some groups, e.g., see Area I cancers for males in Table 4 of the study.

Even though the concentrations of Pu, Am, and other transuranics cited here are small, as will be shown next, their effects inside the body are very damaging to the tissues of the exposed individual if even in these small quantities, cancers and other serious disease almost certainly will occur. For this reason, it is essential that an environment health risk assessment be performed for each activity contemplated within the wildlife refuge and near its boundaries. The record shows that such environmental health risk assessments have not been performed by DOE, EPA, or CDPHE. In fact the environmental health risk assessments that considered residual contamination from Pu, Am, and other transuranics performed by Kaiser-Hill[8] for DOE did not include proper receptor site locations or realistic behavior models. As a result, these health risk assessments did not model the most probable human intake pathways thereby seriously underestimating the total dose workers and residents would receive due to future tollroad-related activities. Furthermore, both JPPHA has reported that comprehensive health risk assessments related to tollroad development activities have been specifically ruled out.

RCRA Facility Investigation Soil Sampling Plan is Seriously Deficient

As an integral part of the Rocky Flats Nuclear Weapons Plant closure activities, DOE conducted a study that is documented in the *RCRA Facility Investigation – Remedial Investigation/Corrective Measures Study – Feasibility Study Report for the Rocky Flats Environmental Technology Site*, June 2006 (RI/FS).[9] The RI/FS divided the site into twelve so-called Exposure Units (EUs) so that each could be analyzed independently regarding levels for specific contaminates of concern, soil characteristics, geological features, and hydrology. Figure 4 shows a map with diagrams of the exposure units that comprise RFNWR—overlaid on the eastern portion of the map is the Indiana Street ROW.

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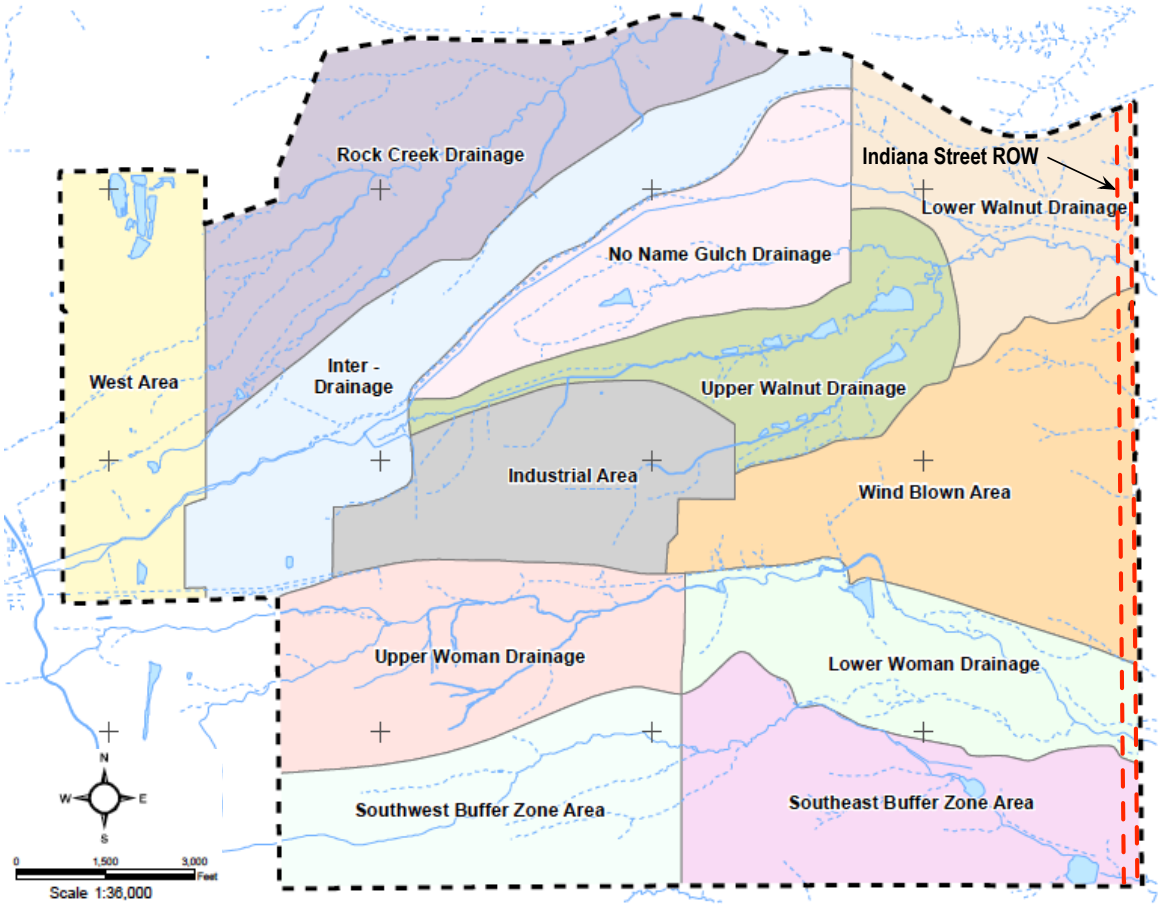
[7] See Carl J. Johnson, *Cancer Incidence in an Area Contaminated with Radionuclides Near a Nuclear Installation*, AMBIO, Volume X, Number 4, 1981, published by the Royal Swedish Academy of Sciences.

[8] The radiological health risk assessments performed by Kaiser-Hill—with EPA approval—modeled a wildlife refuge worker who works in the office 4 hours per day and in the field 4 hours per day but neither of these behaviors models airborne resuspended respirable Pu available for intake in the work area. Again, these health risk assessments yield no information that would bear on the Indiana Street ROW environment when developed for use as a four-lane tollroad.

[9] The Rocky Flats Regulatory Documents including CDs containing the *CRA Analytical Data Sets* generated by the RI/FS are available at: http://www.lm.doe.gov/Rocky_Flats/Regulations.aspx



Source: RCRA Facility Investigation, Volume 9 of 15 - Wind Blown Area Exposure Unit. DOE June 2006.

Figure 4: Rocky Flats National Wildlife Refuge Exposure Units.

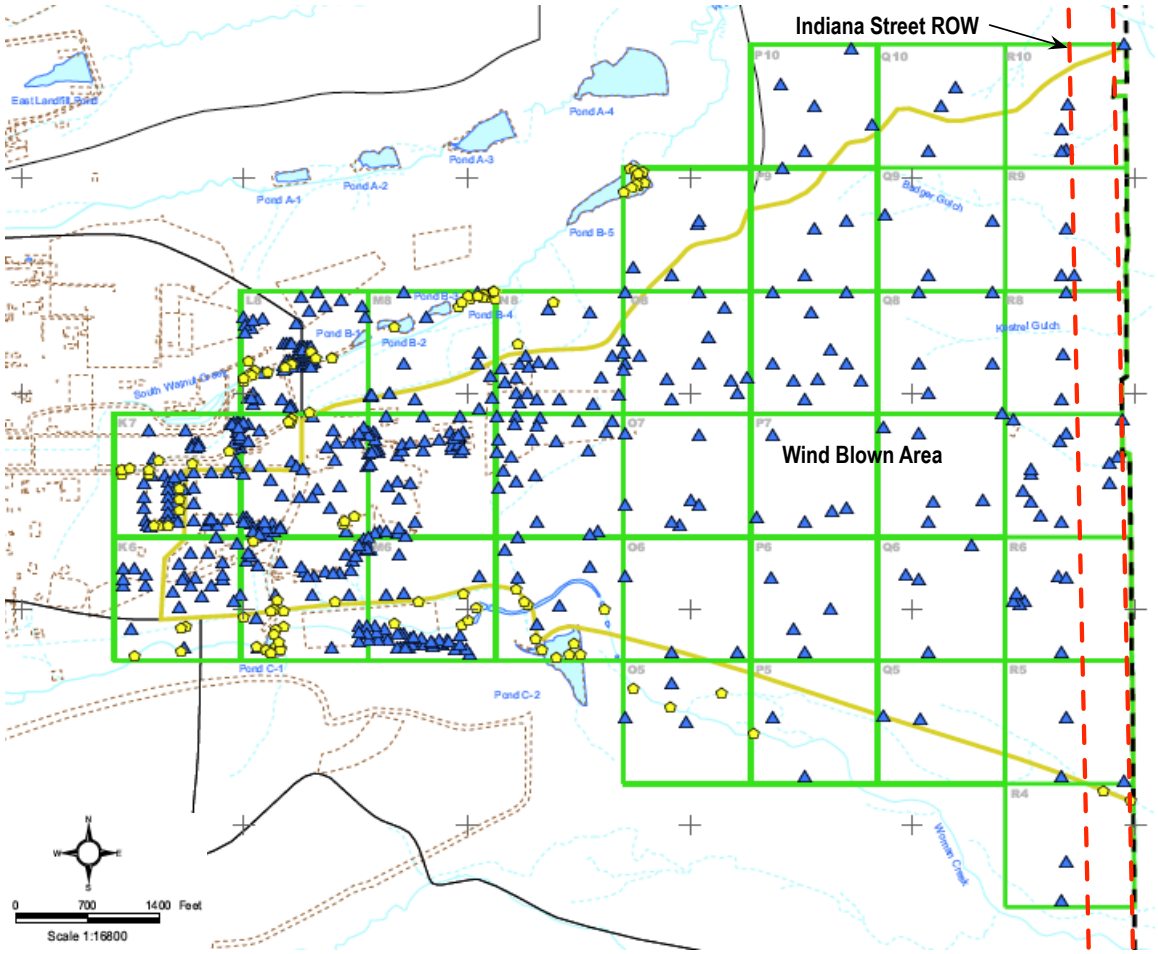
The RI/FS also divided the former Rocky Flats Nuclear Weapons Plan site into a 30-acre grid area to implement a site-wide sampling plan—Figure 5 identifies grid area sites used to sample surface soils and sediments for radionuclides and other contaminants of concern—specifically, within the Wind Blown Area EU. It can be seen that 38 sample sites (36 surface soil plus 2 sediment sites) were selected from within the 210-acre grid area along the Indiana Street ROW—specifically, those within grid designators R4-R10—but only about 10 of these sample sites fall within the area that would become the proposed tollroad ROW within the Wind Blown Area EU (examination of maps for the other EUs show similar lack of adequate ROW sampling).

According to the *Soil Sampling Quality Assurance User's Guide*[10] published by EPA, any situation where there is a previously uncharacterized risk of public exposure to a toxic contaminate requires that a Definitive Study be performed. EPA soil sampling guidelines require that a sampling plan be developed for the site during the initial phase of the required study. Based on an examination of the RI/FS surface soil sample analysis database[11] for grid designators R4-R10, a 95% Confidence Level sampling plan for the Wind Blown Area EU portion of Indiana Street ROW would require between 55-221 random samples taken from within the ROW plus a number of additional samples needed as part of the required QA plan. Similarly, sampling

[10] *Sample Design and Data Analysis - Soil Sampling Quality Assurance User's Guide,* EPA 1989, is available for download at: http://www.epa.gov/esd/cmb/research/bs122.pdf

[11] The Wind Blown Area EU surface soil and surface sediment sample database is contained in *Analytical Data Sets Volume 9 WBEU_061506_YES.*

plans should have been developed for the remaining EUs.[12] The lack of a Definitive Study for radionuclide contamination within the Indiana Street ROW indicates that the public health risk resulting from inhalation and ingestion of airborne respirable Pu, Am, and other transuranics—for tollroad workers as well as for the residents and workers within nearby communities—remains inadequately examined.



Source: RCRA Facility Investigation, Volume 9 of 15 - Wind Blown Area Exposure Unit. DOE June 2006.

Figure 5: Wind Blown Area Exposure Unit Surface Soil and Surface Sediment Sample Locations.

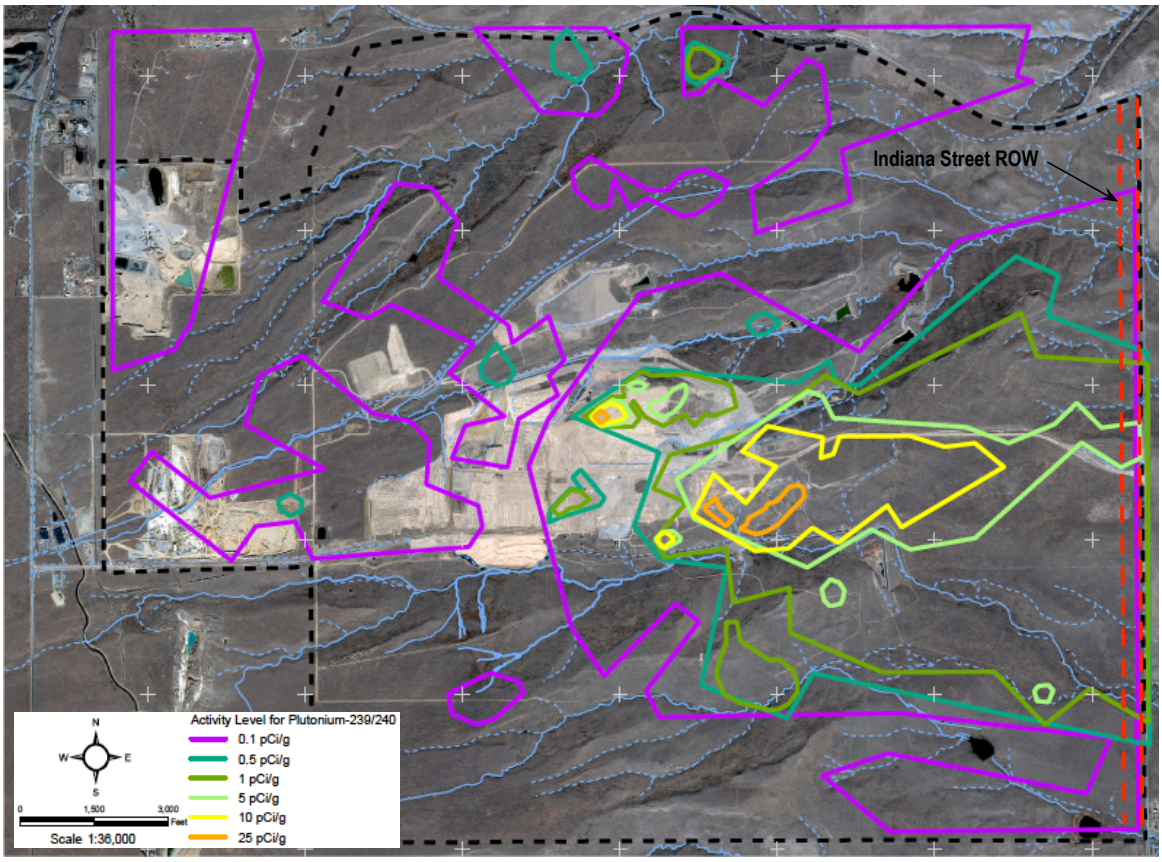
Further examination of the surface soil database shows that from the 36 R4-R10 sample sites, only a small number of samples were actually taken and sent to the laboratory for Pu, Am, and additional transuranics assay. Even using this small number of available samples, the assay showed that the expected average level of Pu contamination within the R-4-R10 grid area is 8-12 pCi/g; however, radionuclide sampling experience shows that there are likely to be a significant number of areas were Pu levels of > 25 pCi/g will exist. These contamination levels are well above levels considered protective of human health and, when the inadequate

[12] From the RI/FS, assay of the initial samples taken within the Wind Blown Area EU showed an average Pu level of 3.9 pCi/g, the maximum value found was 12.8 pCi/g, the Standard Deviation was 4.1 pCi/g, and the Coefficient of Variation was 1.1; therefore, for a 95% Confidence Level, 95% Power t-test with Minimum Detectable Relative Differences of 20% or 40%, the number of samples required is n ≅ 55 or 221 respectively.

soil sampling and radionuclide assay methodologies used during the RI/FS[13] are considered, extreme caution regarding any activity within the Indiana Street ROW is well advised. Moreover, a similar case can be made for the likelihood of high-levels of Pu, Am, and other transuranic element contamination in the Lower Walnut Drainage, Lower Woman Drainage, and Southeast Buffer Zone Area EUs. As a result, the record clearly shows that the fundamental purpose of the RI/FS surface soil and sediment sampling plan has not been met as set out in (10) which states: "The mission of the U.S. EPA is to control environmental pollutants abate potential adverse effects on man and/or the environment. Complying with this mission requires identifying significant sources of pollutants of concern and linking these emission sources to adverse effects upon critical receptors."

RCRA Facility Investigation Air Sampling Mechanisms are Seriously Deficient

An integral part of the RI/FS was an assessment of the potential for contaminants at the former Rocky Flats Nuclear Weapons Plant to become airborne thereby resulting in both dispersal and recontamination of downwind areas by toxins concentrated upwind. Figure 6 shows a map of Pu contamination in the surface soil and sediment that is subject to dispersion and recontamination by moderate-to-strong wind activity.



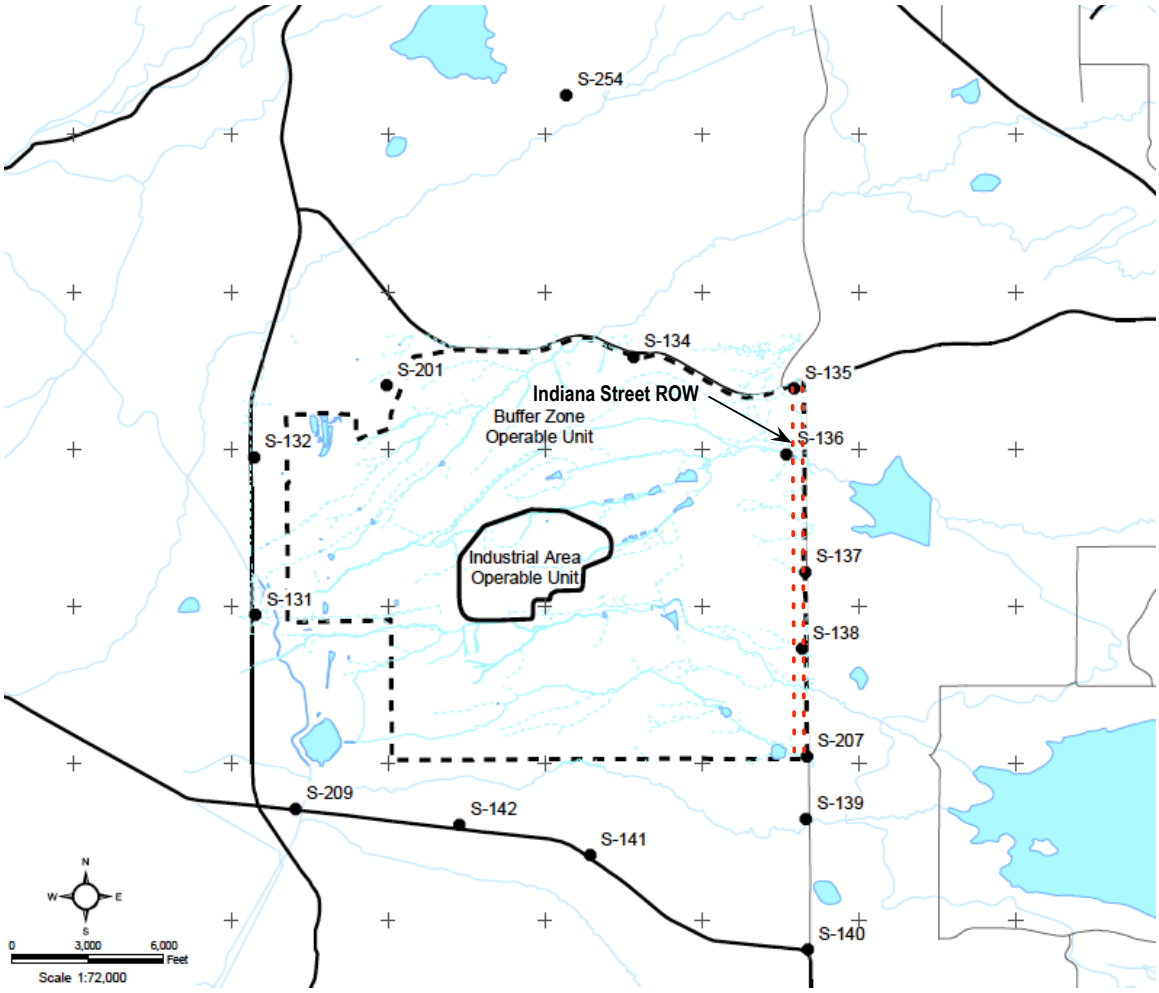
Source: RCRA Facility Investigation, Contaminant Fate and Transport, Section 8: Attachment 2, Future Conditions - Groundwater and Air. DOE June 2006.

Figure 6: Surface Soil and Surface Sediment Sources of Airborne Pu Dispersion.

An examination of the figure shows that there currently exists areas of surface soil and sediment with

[13] The RI/FS soil sampling plan used a process called "kriging" whereby a small number of soil samples are substituted for a larger, properly constructed, and statistically significant number of soil samples, therefore, accounting for the lack of precision in the estimated level of contamination from Pu, Am, and other transuranics.

significant contaminant levels that can act as sources for dispersion of respirable Pu via airborne transport. Additionally, from the outset DOE did not develop a proper set of airborne transport modeling and monitoring methodologies for radionuclides. The technologies that DOE did develop and deploy to monitor stack emissions from the Rocky Flats Nuclear Weapons Plant were so poorly designed that they did not yield any useable information regarding stack emissions during the entire operating life of the plant. The situation regarding air monitoring at the former Rocky Flats Nuclear Weapons Plant is not appreciably better. Figure 7 shows the location of air monitoring stations that were meant to detect the airborne dispersion of radionuclides from the former Rocky Flats Nuclear Weapons Plant.

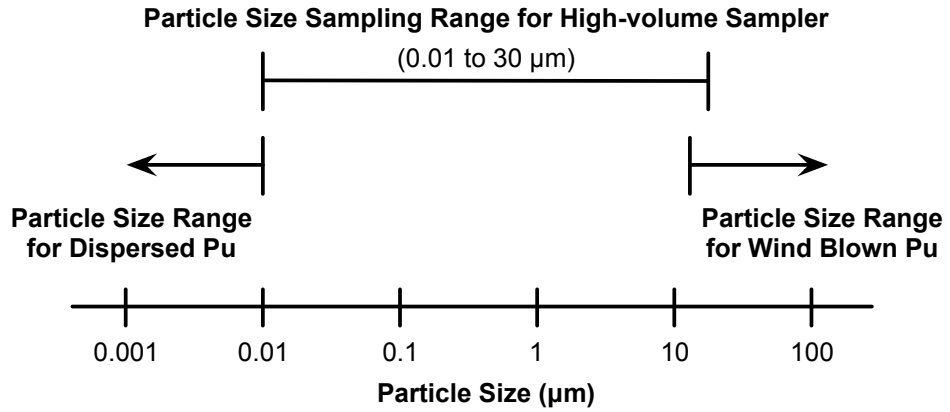


Source: RCRA Facility Investigation, Contaminant Fate and Transport, Section 8: Attachment 2, Future Conditions - Groundwater and Air. DOE June 2006.

Figure 7: Radionuclide Air Monitoring Peripheral Samplers.

Pu, Am, and other transuranics are widely dispersed throughout the former Rocky Flats Nuclear Weapons Plant site; however, due to inadequate air monitoring by DOE it is impossible to determine the exact quantity of radionuclides released but as we have seen in (6), it is believed that the quantity Pu is between 5 and 80 Ci—most of which now resides within the area's surface soils and sediments. Additionally, we know that dispersed Pu particles are extremely small, i.e., on the order of 0.01 μm but that these particles become attached to larger particles, such as dust or pollen, the size of which range from 15 μm to greater than 100 μm. However, it is crucial to understand that, as shown in Figure 8, DOE air monitoring system samplers are

essentially "blind" regarding most of the airborne radionuclide particles blowing off of Rocky Flats.[14] Again, the record shows that the fundamental purpose of the RI/FS air sampling plan has not been met yet, inexplicably, neither EPA nor CDPHE have required that DOE implement a proper air sampling regime at the wildlife refuge.



Source: W. Gale Biggs, Ph.D., Presentation to the Colorado State Legislature, March 17, 2011.

Figure 8: Sampling Range of the DOE High-volume Samplers.

Finally, when the analysis presented above is contrasted with recent statements from DOE, EPA, CDPHE, and USFWS, one can only conclude that an independent EIS regarding the proposed transfer of the Indiana Street ROW is essential.

RCRA Facility Investigation Pu Assay Methodology is Seriously Deficient

As described in the section above entitled *Sources of Contamination from the Rocky Flats Nuclear Weapons Plant*, field work performed during the C.J. Johnson plutonium study analyzed soil samples from within areas of the former Rocky Flats Nuclear Weapons Plant—specifically, an area called Section 7 that spans the Indiana Street ROW. After performing careful radiochemical analysis it was determined that the levels of Pu found within the Section 7 locality were on the order of 60 to 170 dpm/g—consistent with earlier findings by Krey and Hardy—but still far exceeding levels permitted by CDPHE regulations for Pu contaminated soil. The C.J. Johnson plutonium study showed conclusively that the standard methodology for assaying Pu (and other transuranics) seriously underestimates the public health risk due to radionuclide contaminants because these methodologies seriously underestimate the concentrations available for resuspension and inhalation.

Table 1 below shows the results of the C.J. Johnson assay methodology for respirable Pu when compared with the results of the same sample using standard radiochemical analysis. Note that standard Pu assay methodologies do not estimate respirable Pu dust concentrations within surface soil samples, and therefore the risk to the public health due to the effects of respirable Pu, are underestimated by a factor of between 6 and 12.

Table 1: Comparison of C.J. Johnson Pu Assay Methodology with Standard Methodology.

C.J. Johnson Methodology Analyses of Pu in Respirable Dust			Standard Pu Analysis Methodology
Locality	**Respirable Dust %**	**Pu in Respirable Dust (dpm/g)**	**Pu (dpm/g)**
Section 7-1	**36.1**	**83**	**13.5**

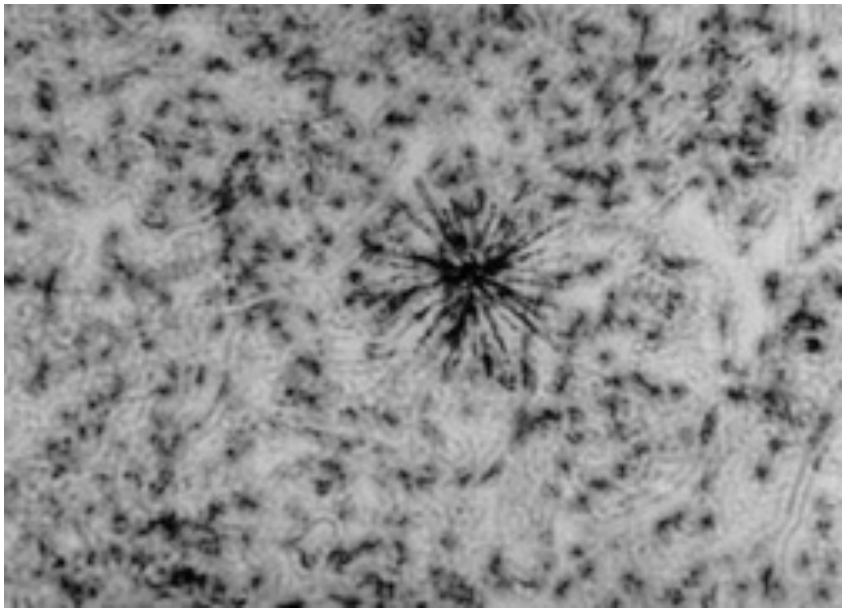
[14] From W. Gale Biggs, Ph.D., *Presentation to the Colorado State Legislature, March 17, 2011.*

C.J. Johnson Methodology Analyses of Pu in Respirable Dust			Standard Pu Analysis Methodology
Locality	Respirable Dust %	Pu in Respirable Dust (dpm/g)	Pu (dpm/g)
Section 7-2	41.4	59	--
Section 7-3	17.9	120	14.1
Section 7-4	18.8	170	--

Both EPA and CDPHE should adopt the Pu assay methodology used in the C.J. Johnson plutonium study since it more accurately reflects the actual public health risk due to airborne respirable Pu, Am, and other transuranics in the surface soils and sediments under study.

Public Health Risks Due to Resuspended Respirable Plutonium

While all transuranic elements present a significant health risk to humans (or any other long-living animal), ^{239}Pu is especially harmful when it is respired into the lungs, ingested orally, or enters the bloodstream through an open wound e.g., a child's scrapped knee. Because the ^{239}Pu atom is a strong emitter of alpha radiation, when a particle as small as ≤ 5 μm across enters human body, its effects on surrounding tissues, typically 10,000 neighboring cells, shown in Figure 9, are devastating.



Source: Robert Del Tredici at Lawrence Radiation Laboratory, Berkeley, California, September 20, 1982.

Figure 9: Effect of Particle of Plutonium in Lung Tissue.

Figure 9 shows the effects of an invisible particle of ^{239}Pu when it is deposited in lung tissues. The ^{239}Pu particle cannot be seen even though the magnification is 500 times normal; however, the black star in the middle of the photo shows tracks made by emitted alpha particles within the otherwise healthy lung tissue (in this case, of an ape). When one of the cells of living lung tissue within range of the radioactive ^{239}Pu particle is damaged, it can become a cancer cell that multiplies and spreads throughout the lung risking health and endangering life.

Conclusions from Radionuclide Exposure Epidemiological Studies: Several epidemiological studies have shown that, once it enters the body, a certain proportion of the ^{239}Pu (depending on the intake pathway) will enter the bloodstream eventually finding its way to the liver and bone marrow as well as to the endocrine

and the gonadal organs where these particles will become attached—almost certain to cause cancers, hormonal and reproductive abnormalities, and serious damage to other organs of the body through secondary disease. Epidemiological studies have also shown that the specific effects of ^{239}Pu are highly dependent on the age, sex, and circumstances of the receptor e.g., the fetus of a pregnant woman in her first trimester is highly susceptible to genetic damage (due to the rapid cell division that takes place at this stage of fetal development); children of any age are generally 10 times more effected by a specific Pu dose compared to an adult; and, finally, teenagers undergoing puberty are highly susceptible to genetic damage of the reproductive organs leading to sterility or, even worse, genetic mutations in generations thousands of years into the future.[15] Furthermore, since ^{239}Pu is not water soluble and has a half-life of 24,100 years, it persists not only within the body where it continues to harm cellular tissues but also within the local environment where it remains available in respirable form for resuspension in the air ready for inhalation by those who live and work in the surrounding and downwind communities.

C.J. Johnson Epidemiological Study: The Denver, Colorado area cancer incidence study published by the late Carl J. Johnson, MD 1981 (7) found significant excess cancers for male and female Anglo populations within three areas—Areas I, II, and III near the former Rocky Flats Nuclear Weapons Plant—when compared to the portion of the state population living and working far from the former plant site (Area IV). Just a few of the most significant excess cancers found for the 1969-1971 period of study are listed below:

- A 24% and 15% increase in all male cancers in Areas I and II respectively;
- A 10% and 5% increase in all female cancers in Areas I and II respectively;
- A 42% increase in colorectal cancer in Area I males and females; and
- A 58% increase in leukemia in Area III females.

Dr. Johnson observers in the study, "The excess cancers were mainly leukemia, lymphoma and myeloma and cancer of the lung, thyroid, breast, esophagus, stomach and colon, a pattern similar to that observed in the survivors of Hiroshima and Nagasaki."

G.S. Wilkinson Epidemiological Study: The epidemiological study of 5,413 Rocky Flats Nuclear Weapons Plant workers published by Gregg S. Wilkinson, Ph.D. of Los Alamos National Laboratory in 1987[16] found elevated rate ratios for all causes of death as well as for all lymphopoietic neoplasms when employees with Pu body burdens $\geq$ 2 nCi were compared with those with body burdens < 2 nCi, while accounting for age, calendar period, and induction time. Additionally, increased rate ratios were found for esophageal, stomach, colon, and prostate cancers, and for lymphosarcomas and reticulum cell sarcomas. When employees with cumulative exposures $\geq$ 1 rem were compared with those with exposures < 1 rem, elevated rate ratios were found for myelold leukemia, lymphosarcoma and reticulum cell sarcoma, liver neoplasms, and unspecified brain tumors were found.

Standardized rate ratios increased as Pu body burden levels increased for all causes, all cancers, and digestive cancers at live years induction time. Standardized rate ratios also increased as external radiation exposure categories in creased for all lymphopoletic cancers and unspecified brain tumors for a two-year induction period. Except for analyses of combined categories of death, and of lung cancer, confidence limits were moderately wide resulting in a reduction in precision. Nevertheless, these findings suggest that increased risks for several types of cancers cannot be ruled out at this time for individuals with plutonium body burdens of $\geq$ 2 nCi and that Pu-burdened individuals should continue to be studied in future years.

L.S. Newman Epidemiological Study: The recent retrospective epidemiological study of Rocky Flats Nuclear Weapons Plant workers published by Lee S. Newman, MD of the National Jewish Medical and Research Center, Division of Environmental and Occupational Health Sciences in 2002[17] evaluated the lung

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[15] No studied toxin-induced genetic mutation in animals has ever been found to be beneficial.

[16] See Gregg S. Wilkinson et. al., *Mortality among Plutonium and Other Radiation Workers at a Plutonium Weapons Facility*, American Journal of Epidemiology 125, 2 (1987): 231-250.

[17] See Lee S. Newman et. al., *Lung Fibrosis in Plutonium Workers*, Division of Environmental and Occupational Health Sciences National Jewish Medical and Research Center, 1400 Jackson Street, Denver CO 80206.

radiographs of 326 Pu-exposed workers compared to 194 plant workers who had no Pu exposure. The study compared the severity of chest radiograph interstitial abnormalities between the two groups using the International Labour Organization (ILO) profusion scoring system.

When not controlling for other effects, there was found to be a significantly higher proportion of abnormal chest radiographs among Pu workers (17.5%) as compared to non-exposed workers (7.2%). Of those Pu workers with absorbed lung doses between 1-5, 5-10, and > 10 Sv increased risks for pulmonary fibrosis of 1.9, 3.8, and 7.7 times were observed, respectively. When the study controlled for effects of age, smoking and asbestos exposure, lung dose of 10 Sv or greater conferred a 5.3-fold risk of having an abnormal chest x-ray consistent with pulmonary fibrosis when compared to non-exposed individuals. Generally, the study concluded that inhaled Pu may cause lung fibrosis in humans at absorbed lung doses above 1 Sv.

National Academy of Sciences Radiation Exposure Study: It is crucial to understand that there is simply no safe level of exposure to ionizing radiation (in the present case, radiation from plutonium, americium, strontium, radium, and uranium): in its recent report to Congress entitled *Health Risks from Exposure to Low Levels of Ionizing Radiation* (BEIR VII)*, 2006*, the National Academy of Sciences (NAS) categorically affirms that even small doses of radiation add to an individual's cumulative risk of developing various cancers and other diseases. Importantly, the NAS has recommended that the current EPA cancer risk factor of 8.46×10^{-4}/rem be raised to 11.4×10^{-4}/rem i.e., the threshold for the risk of cancer due to radionuclide intake has been lowered considerably.

Transfer of the Indiana Street ROW Requires a Thorough Environmental Impact Statement

As presented above, the radiological health science indicates that the public health will be additionally endangered if large-scale development along the 300-foot wide right-of-way were allowed to occur. Therefore, it is clear that USFWS must leave RFNWR completely undeveloped—the risk to public health during the construction and operation of a tollroad, due to airborne resuspended respirable Pu, Am, and other transuranics, is just too great. Under Section 4(e)(1)(D) of the Act, the Secretaries of the Departments of Energy and of the Interior are required to comply with applicable law, specifically, the Secretaries are required to comply with the provisions of CERCLA. The FONSI issued by USFWS without first conducting a thorough EIS violates not only the Act but the provisions of CERCLA, NEPA, and other federal law. The FONSI in this instance also represents a breach of the Secretaries' duty to protect the health and safety of the public.

Finally, due to the inadequacies of the environmental health risk assessments cited above a thorough EIS must, at a minimum, include extensive surface and subsurface soils sampling, soil core sampling, and water table sampling as part of a complete radiochemical analysis regime that can establish a baseline profile for radionuclide contamination. Evaluation of the surface soil and sediment for radionuclide contaminates should use the plutonium assay methodology developed by C.J. Johnson. Additionally, a rigorously designed air sampling regime must be implemented and a study of the probable rapid migration of radionuclides into the Indiana Street ROW due to a 500-year flooding event at Rocky Flats must be performed. It is likely that such a thorough EIS will show conclusively that the entire Rocky Flats site (as well as certain areas external to its boundaries) must remain completely undeveloped and that some of these areas may require additional ameliorative action by DOE.

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